RADIATION HAZARD ANALYSIS
9.0 M C-band Antenna CC-1

Introduction

In compliance with the FCC's Rules and Regulations, a radiation hazard study has been completed for this modification to the existing PanAmSat Licensee Corp. transmitting earth station located at Castle Rock, Co.. This study takes account of the FCC's new radiation hazard analysis as contained in OET Bulletin 65 issued in August 1997 and the ANSI radiation guidelines with respect to human exposure to radio frequency electromagnetic fields in the range 1500 MHz to 100 GHz. In this range the maximum power density is set at 1.0 mW/cm² for general population/uncontrolled exposure and 5.0 mW/cm² for occupational/controlled exposure.

General Discussion

Because of the highly directive nature of aperture antennas, the possibility of human exposure to RF radiation is considerably reduced from what would be the case in standard broadcasting antennas. For the antenna described in this application, the power densities, which might exist at locations where human exposure is possible, are substantially less than the on-axis power of this antenna. Thus strict operational procedures by the earth station operator concerning main beam orientation, antenna height above ground, and the relative location to where people live or work will lead to minimum exposure potential for the earth station being applied for in this application.

Technical Discussion - Fresnel Zone

The parabolic antenna described in this application has a circular cross section. For antennas of this design, the near field, or Fresnel region, main beam power density can be described by the following equation:

$$R_{(nf)} = D^2 / 4\lambda$$

where: $R_{(nf)}$ = distance to the near field (*meters*)

D = diameter of antenna (*meters*)

λ = transmit frequency wavelength (*meters*)

Technical Discussion - Fresnel Zone (continued)

For this application, $D = 9$ *meters*

$\lambda = 0.048583$ at 6.175 GHz

Thus the distance to the end of the near field is:

$$R_{(nf)} = (9)^2/4(0.048583)$$

$$R_{(nf)} = 416.81$$

The magnitude of the flux density of the beam (on-axis) will vary according to the location in the near field. The maximum value of the near-field on-axis power density ($S_{(nf)}$) is given by the following equation:

$$S_{(nf)} = 16\eta P / \pi D^2$$

where: η = antenna efficiency

P = power fed to the antenna (*watts*)

D = antenna diameter (*meters*)

For this application, $\eta = 0.6$

$P = 500$ *watts*

$D = 9$ *meters*

Thus the near field maximum power density is:

$$S_{(nf)} = 16(0.6)(500) / \pi(9)^2$$

$$S_{(nf)} = 4800/254.47 = 18.9 \text{ watts/m}^2 = \mathbf{1.89\ mW/cm^2}$$

For off-axis calculations in the near field, it can be assumed that, if the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point would be at least a factor of 100 (20 dB) less than the value calculated for the equivalent distance in the main beam.

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Technical Discussion - Fresnel Zone (continued)

$$S_{(nf)Off\ Axis} = \mathbf{0.018\ mW/cm^2}$$

Since the antenna diameter is 9.0 meters, the distance required for a 20 dB reduction in power density is 9.0 meters from the center of the main of the antenna.

The applicant agrees to prevent the presence of human beings in the entire area in front of the antenna in all directions except the backside of the antennas where the signal is further attenuated, through the installation of barriers, fencing and signs, or other approaches to keeping people away during times of transmission.

Technical Discussion - Transition Region

Power density in the transition region decreases inversely with distance from the earth station antenna. On-axis power density in the transition region can be estimated by use of the following equation:

$$S_{(t)} = S_{(nf)} R_{(nf)} / R$$

where: $S_{(t)}$ = power density in transition region

$S_{(nf)}$ = maximum power density for near field

$R_{(nf)}$ = extent of the near field

R = distance to point of interest

In this application, the earth station is located within a secured fenced area. The point of interest within the transition region would be outside of the fenced area and 2 meters above the ground level in the direction of the worst case elevation angle. Using the worst case elevation angle of 24.1° and a point just beyond the extent of the near field

Technical Discussion - Transition Region (continued)

at 708 meters, the power density at that point can be calculated using the above equation and simple trigonometry for the off axis calculations.

$$S_{(nf)} = 18.9\ W/m^2$$

$$R_{(nf)} = 416.81\ meters$$

$$R = 708.58\ meters$$

Thus: $S_{(t)} = (18.9)(416.81) / (708.58) = 11.09577$ watts/m²

$$S_{(t)} = \mathbf{1.11\ mW/m^2}$$

Technical Discussion - Fraunhofer Region

Power in the far-field or Fraunhofer region decreases inversely as the square of the distance. The distance to the beginning of the far field region ($R_{(ff)}$) can be expressed by the following equation:

$$R_{(ff)} = 0.6D^2/\lambda$$

where: D = antenna diameter

λ = wavelength of the frequency being transmitted

In the case of this installation, the far field will begin at:

$$R_{(ff)} = 0.6(9)^2/0.048583$$

$$R_{(ff)} = \mathbf{1000.35}\ meters$$

Technical Discussion - Fraunhofer Region (Continued)

The power density for the far-field region is given by the following equation:

$$S_{(ff)} = GP \big/ 4\pi \left(R_{(ff)}\right)^2$$

where: $S_{(ff)}$ = maximum power density in the far field

G = gain of the antenna at the given efficiency

P = power into the antenna

$$S_{(ff)} = (239{,}883)(500)/4\pi(1000.35)^2$$

$$S_{(ff)} = 9.537975 \textit{ watts/m}^2$$

$$S_{(ff)} = \mathbf{0.95\ mW/cm^2}$$

Technical Discussion - Region Between Feed Flange and Reflector

Transmissions from the feed horn are directed toward the reflector surface, and are confined within a conical shape defined by the feed. The maximum power density between the feed and reflector surface ($S_{(f)}$) can be determined using the following equation:

$$S_{(f)} = 4P \big/ A_{(f)}$$

where: P = power into antenna

$A_{(f)}$ = area of feed flange

$$S_{(f)} = 4(500 \textit{ watts}) \big/ 8.155 \textit{ cm}^2$$

$$S_{(f)} = 245.248 \textit{ watts/cm}^2$$

$$S_{(f)} = \mathbf{245{,}248\ mW/cm^2}$$

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Technical Discussion - Reflector Surface Region

The power density at the surface of the main reflector region ($S_{(r)}$) is determined using the same equation as above, but with the area of the reflector as shown below:

$$S_{(r)} = 4P/A_{(r)}$$

where: P = power into antenna

$A_{(r)}$ = area of reflector aperture

$$S_{(r)} = 4(500\ watts)/636{,}173\ cm^2$$

$$S_{(r)} = 0.003144\ watts/cm^2$$

$$S_{(r)} = \mathbf{3.14}\ \boldsymbol{mW/cm^2}$$

Technical Discussion - Region Between Antenna and Ground

Assuming uniform illumination of the reflector surface, the power density between the antenna and ground ($S_{(g)}$) can be calculated as follows:

$$S_{(g)} = P/A_{(r)}$$

where: P = power into antenna

$A_{(r)}$ = area of reflector aperture

$$S_{(g)} = 500\ watts/636{,}173\ cm^2$$

$$S_{(g)} = 0.000786\ watts/cm^2$$

$$S_{(g)} = \mathbf{0.79}\ \boldsymbol{mW/cm^2}$$

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Summary Tables of Radiation Values for
General Population/Uncontrolled Exposure And Occupational/Controlled Exposure

		General Population/Uncontrolled Exposure Max Radiation Level **(1.0 mW/cm²)**	Occupational/Controlled Exposure Max Radiation Level **(5.0 mW/cm²)**
Region	**Radiation Level**	**Hazard Assessment**	**Hazard Assessment**
Near Field $R_{(nf)} = 416.81\ m$	0.018 mW/cm² (off-axis)	Complies with Guidelines	Complies with Guidelines
Far Field $R_{(ff)} = 1000.35\ m$	0.95 mW/cm²	Complies with Guidelines	Complies with Guidelines
Transition Region $R_{(nf)} < R_{(t)} < R_{(ff)}$	< 0.011 mW/cm² (off-axis)	Complies with Guidelines	Complies with Guidelines
Region Between Feed Flange and Reflector	245,248 mW/cm²	Potential Hazard	Potential Hazard
Reflector Surface Region	3.14 mW/cm²	Potential Hazard	Complies with Guidelines
Region Between Antenna and Ground	0.79 mW/cm²	Complies with Guidelines	Complies with Guidelines

The above analysis shows that harmful levels of radiation will not exist in regions normally occupied by the public or the earth station's operating personnel. The earth station is located within a secured fenced facility where access is controlled and unauthorized personnel are not permitted. The earth station will be marked with the standard radiation hazard warnings, on the antenna itself, warning personnel to avoid the area in front of the reflector when the transmitter is operational. Additionally, the orientation of the earth station will be controlled and continually monitored to ensure that the general public and the earth station's operating personnel are not exposed to radiation levels greater than the allowed maximums. To ensure compliance with the safety limits, the earth station transmitter will be turned off whenever maintenance and repair personnel are required to work in the area where the radiation level exceeds the level recommended by applicable guidelines.